

# **EXHIBIT D-7**

**Estimated Quantities  
Of  
Aqueous Film Forming Foam (AFFF)  
In The  
United States**

Prepared for the Fire Fighting Foam Coalition  
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## **Executive Summary**

Aqueous film forming foam (AFFF) is the premier fire fighting foam in the U.S. and many parts of the world. Its ability to rapidly extinguish flammable liquid pool fires is unmatched by any other agent. AFFFs are synthetically formed by combining fluorine-free hydrocarbon foaming agents with highly fluorinated surfactants. When mixed with water, the resulting solution achieves the optimum surface and interfacial tension characteristics needed to produce an aqueous film that spreads across the surface of a hydrocarbon fuel. It is this film formation feature that provides superior fire extinguishment and is the source of the designation – aqueous film forming foam.

In May 2000 the 3M Company announced the phaseout of production of products made with perfluorooctanyl chemistry, including AFFF, because of the widespread presence of perfluorooctyl sulfonate (PFOS). Fluorosurfactants used in 3M's AFFF were produced by a unique process known as electrochemical fluorination (ECF). Other manufacturers of AFFF use fluorosurfactants produced by a telomerization process. These products, commonly referred to as telomers, neither contain nor break down into PFOS. Because of EPA's continuing interest in fluorosurfactants, the Fire Fighting Foam Coalition (FFFC) voluntarily committed to provide EPA with an estimate of nation-wide inventories of ECF-based and telomer-based AFFFs. FFFC commissioned Hughes Associates, Inc. to assist in collecting the data and drafting the report.

Quantities of AFFF in this report are expressed as gallons of concentrate. In the foam industry, concentrates are typically referred to as "3 %" or "6 %" concentrate, depending on the mixture rate with water (a fire fighting foam solution made from "3 %" concentrate will consist of 97 parts water to 3 parts AFFF concentrate). AFFF concentrates contain about 60-90% water and have a fluorine content of about 0.3-1.8%.

Essentially all AFFF procured in the U.S. is specified to conform to either a foam standard of Underwriters Laboratory (UL) or a more stringent military specification (MilSpec). Generally speaking, MilSpec AFFFs contain more fluorosurfactant and more fluorine than UL agents. Similarly, ECF-based AFFFs contain more fluorine than telomer-based AFFFs. Accordingly, in addition to estimating the total amount of AFFF and the corresponding use sectors, an attempt was also made to determine the relative amounts of UL, MilSpec, ECF-based and telomer-based AFFF concentrates.

The report concludes that the total inventory of AFFF in the U.S. is approximately 9.9 million gallons, within an overall estimating range of about  $\pm 20\%$ . Roughly 55 % of the overall total is estimated to be telomer-based concentrate and about 45% to be ECF-based concentrate. Almost two thirds of the MilSpec AFFF concentrate is ECF-based.

The major use sector is the U.S. military, followed closely by oil refineries and other petrochemical industries. Civil aviation is another major user, for airport rescue and fire fighting vehicles as well as for protection of aircraft hangars. Municipal fire departments throughout the country are collectively a major use sector as well.

## **Background**

In May 2000 the 3M Company announced the phaseout of production of products made with perfluorooctanyl chemistry, including AFFF, because of the widespread presence of perfluorooctyl sulfonate (PFOS). PFOS-based products were produced by a unique process called electrochemical fluorination (ECF). 3M's decision did not have a direct impact on the production and availability of other AFFF agents because these agents contain fluorosurfactants produced by a telomerization process. Such products are generally referred to as telomers. Telomer-based fluorosurfactants neither contain nor break down into PFOS.

A workgroup of the Environmental Protection Agency (EPA) recently determined that telomer-based AFFF agents are not likely to be a source of perfluorooctanoic acid (PFOA) or its homologues in the environment and do not have to be tested as part of the ongoing enforceable consent agreement (ECA) process. Based on EPA's continued interest, the Fire Fighting Foam Coalition (FFFC) voluntarily committed to provide EPA with data on inventories of ECF-based and telomer-based fire fighting foams. FFFC commissioned Hughes Associates, Inc. to assist in collecting the required data and drafting a report.

## **Role and Evolution of AFFF**

Shortly after its commercial introduction in the mid-1960s, AFFF rapidly evolved as the primary fire fighting foam in the U.S. and many parts of the world. AFFF provided superior performance over normal Protein foam, which had been in wide spread use since World War II.

Protein foam is made from a mixture of hydrolyzed protein, together with various dissolved metal salts, surfactants and expansion improvers. Hoof and Horn meal or chicken feather meal are examples of protein sources within protein-based foams. Aqueous film formation over the surface of fuels is not a characteristic of normal protein foams. Some specialized protein foams are now available with aqueous film formation characteristics which are derived by mixing protein foam with selected fluorosurfactants. Proteinaceous foams have little appeal or current wide spread use within the U.S., but retain popularity in some foreign territories and are manufactured in the U.S. The overwhelming majority of fire fighting foam used within the U.S. is of the AFFF variety.

AFFFs are synthetically formed by combining fluorine-free hydrocarbon foaming agents with highly fluorinated surfactants. When mixed with water, the resulting solution achieves the optimum surface and interfacial tension characteristics needed to produce a film that will spread across a hydrocarbon fuel. It is this film formation feature that provides superior fire extinguishment and is the source of the designation – aqueous film forming foam. AFFFs that are compatible with water-miscible fuels, such as alcohol, are

known as alcohol resistant AFFF. Essentially all AFFF marketed in the U.S. is listed by Underwriters Laboratory (UL) based on conformance with UL Standard 162, "Foam Equipment and Liquid Concentrates" or has been certified by the U.S. Naval Research Laboratory as meeting the requirements of the Department of Defense Military Specification, Mil-F-24385, "Fire Extinguishing Agent, Aqueous Film Forming Foam".

Commercially available protein foams include Protein, Fluoroprotein, and Film Forming Fluoroprotein (FFFP) foams. Disposition of all these types of protein-based foams, with little U.S. utilization, are not addressed within this paper.

## **Constituents of AFFF Concentrate**

Quantities of AFFF in this report are expressed as gallons of concentrate. In the foam industry, concentrates are typically referred to as "3 % concentrate" or "6 % concentrate", or respectively as Type 3 or Type 6 foam, depending on the mixture rate with which the concentrate is dissolved in water. A 3 % (or Type 3) AFFF concentrate will be mixed into a "solution" consisting of 3 parts concentrate to 97 parts water before being applied to the fire. Similarly, a fire fighting foam solution of a 6 % (or Type 6) AFFF will be proportioned at 6 parts concentrate to 94 parts water. Stated differently, for every 100 gallons of foam solution applied to a fire, if it is made with a Type 3 foam, only 3 gallons of concentrate will be used. Foam fire fighting discharge devices, such as AFFF sprinkler heads or roof turrets on an airport crash truck, are commonly referred to by their foam solution application rate, expressed as gallon per minute (gpm) of foam solution. Hence, when a 3 % concentrate is used, a 1000 gpm AFFF nozzle is actually flowing only 30 gpm of concentrate, with the balance being water. Additionally, when considering the amount of "chemicals" discharged to the environment during the application of foam to a fire, it should be understood that even the concentrate itself is mostly water.

Presented below is a breakdown of the average constituents on a weight basis of four typical 3% (or Type 3) AFFF concentrates: ECF-based agents meeting UL specifications; ECF-based agents meeting military specifications; telomer-based agents meeting UL specifications; and telomer-based agents meeting military specifications. In order for an agent to meet military specifications it must pass certain testing requirements at half strength, therefore, MilSpec agents generally contain more fluorosurfactant and more fluorine than UL agents. Telomer-based AFFF agents contain on average about 30-60% less fluorine than ECF-based agents.

## Average Constituents of 3% AFFF Concentrates

	ECF UL	ECF MilSpec	Telomer UL	Telomer MilSpec
Water	68%	69-71%	68-93%	60-77%
Solvents	25%	20%	3-20%	10-20%
Hydrocarbon Surfactant Actives	2%	4%	3-8%	5-12%
Fluorinated Surfactant Actives	4%	5%	1-3%	2-5%
Fluorine Content	0.9%	1.8%	0.3-0.9%	0.7-1.2%
Other*	1%	1%	0.3-2%	1-5%

\* Other includes corrosion inhibitors, electrolytes, pH buffers, etc.

## Major Use Sectors

For purposes of this report, deployed quantities of AFFF have been segregated into major use sectors, depending on the governmental or industrial category of the end user and the nature of the application. The method of estimating AFFF quantities within each use sector varied as a function of the availability of an existing database of AFFF inventory within that sector. In some cases, such as with the U.S. Military, central offices within each service were able to provide fairly accurate data on their facilities and end use applications of AFFF. Accordingly, reasonably accurate predictions of total inventory data for such a use sector were attainable through assembly, tabulation, itemization and summation of reported amounts. In other use sectors, where no central database or overseeing authority existed upon which to draw information, estimates had to be based on sampling and extrapolation techniques. Finally, there were some sectors where reliance was placed on the professional opinion and/or educated guesses of persons familiar with AFFF deployment within that use group. In support of the estimates derived for each sector, the following discussion presents a description of how and why AFFF is used in that sector, the method used to determine the estimated AFFF quantities, and the degree of accuracy in the final numbers. A detailed description of the sources of information, including references, e-mails, and phone logs, is presented at the end of the report as Appendix A.

### U.S. Military

Applications: AFFF is vital to the fire protection posture of the U.S. military. This is not surprising in view of the fact that flammable liquids are essential to military operations, primarily as propulsion fuel for military vehicles, aircraft and ships. Because of the quantities of flammable liquids and the unique hazard of military operations, DOD agencies have always played a major role in the development and deployment of fire fighting foams (in fact, the original patent on AFFF is held by the Naval Research Laboratory). Military departments have been leaders in developing systems and

techniques for utilizing AFFF to counter various flammable liquid fire threats. The U.S. military specification (MilSpec) for AFFF has become the standard of excellence for AFFF performance, and is frequently cited in procurement specifications in civilian applications.

The primary advantage of AFFF, relative to other foam products, is the speed with which AFFF can control and extinguish fires involving pools or spills of flammable liquids. Typically in military operations, speed of extinguishment of flammable liquid fires is essential, as is the case when fire is exposing ordnance hanging under the wing of an aircraft, aircrews are trapped inside a fuselage surrounded by fire, high value aircraft are undergoing repair and maintenance in a hangar facility or engine test facility, fuel is burning in a bilge of a ship, armed and fueled landing craft are packed into the well deck of an amphibious vessel, or large military fuel farms are threatened. To counter these threats, large quantities of AFFF are deployed in fixed fire suppression installations, airfield crash trucks, most military fire department pumper apparatus, and an assortment of hose-delivered manual fire fighting systems. Specific examples of military applications are as follows:

**Ships** – On a typical aircraft carrier the entire 4 1/2 acre flight deck is protected by several hundred nozzles built into the steel flight deck that can be activated remotely to cover any portion of the deck with AFFF to protect against fires involving fueled and armed aircraft. The entire aircraft hangar deck is protected by an overhead AFFF deluge sprinkler system, as are fuel pump room and machinery space bilges. AFFF hose stations are also distributed around the ship in areas containing flammable liquids. Each Nimitz Class aircraft carrier carries approximately 20,000 gallons of AFFF concentrate. Nearly all Navy, Coast Guard and larger Army watercraft deploy AFFF in similar systems.

**Shore Facility Installations** – Fixed AFFF systems would be used to protect hazardous locations such as aircraft hangars, jet engine test facilities, hot refueling sites, flammable storage areas and fuel farms. Large hangars may each contain in excess of 1,500 gallons of concentrate, with some larger hangars containing 5,000 gallons or more.

**Fire Fighting Vehicles** - Most military airfields are protected by aircraft rescue and fire fighting (ARFF) vehicles. As is the practice at civilian airports, military ARFF vehicles carry AFFF. Large airfields may have five or more ARFF vehicles, each carrying about 200 gallons of AFFF concentrate. Additionally, most military fire department structural pumpers also carry AFFF for combating miscellaneous flammable liquid fires.

Method of Analysis: Fire protection functional specialists were contacted at the headquarters level of each military service or DOD agency. They either already had an existing inventory of AFFF in systems or applications under their purview or they put out a data call to their field activities to obtain the required information.

Estimated Quantities (Gallons of AFFF Concentrate): AFFF quantities in the U.S. military, including the U.S. Coast Guard, are itemized in the following table.

<b>Military Service</b>			<b>Service Total (Gals)</b>
Navy			1,249,563
	Ships	678,150	
	Shore Fixed Systems	238,000	
	Air Station ARFF	26,284	
	Foam Tenders	8,500	
	Structural Pumpers	22,408	
	On-Base Reserve	80,573	
	Marine Corps	20,718	
	Military Sealift	174,930	
Army			116,000
	Fixed Systems	40,000	
	Fire Departments	20,000	
	Vessels/Watercraft	56,000	
Air Force			1,327,534
	Air Base ARFF	188,406	
	Station Reserve	201,969	
	Fixed Systems	699,219	
	Supply System	237,940	
DLA			1,000
Coast Guard			142,400
	Fire Departments	122,400	
	Ships	20,000	
		<b>Grand Total</b>	<b>2,836,497</b>

Table 1 AFFF in U.S. Military (Installed Base)

**Total estimate for the “U.S. Military” use sector = 2,836,500 gallons**

Accuracy of the Estimate: The scope of this paper is confined to AFFF quantities within the 50 U.S. states. Accordingly, known AFFF amounts owned by the U.S. military but located on U.S. military bases in foreign countries were purposely omitted. However, some of the listed quantities were in mobile military assets, such as Navy ships or Marine expeditionary units. These assets, by their nature, are sometimes in and sometimes out of U.S. territorial waters. No attempt was made to estimate, for example, how much of the U.S. fleet having AFFF would be in the U.S. at any given time – so all of the military ship data is assumed to be part of the total inventory “in the U.S.”

Subject to the above-stated caveat, the military sector data is considered to be the most accurate of any of the designated use sectors.

### **Other Federal Agencies**

Applications: AFFF use at other (non-DOD) agencies is limited to those few agencies that handle significant quantities of flammable liquids. AFFF would be used in overhead sprinkler systems, small quantities on fire department apparatus, and some systems protecting special hazards. A good example of AFFF usage for special hazard protection would be AFFF systems protecting the Department of Energy Strategic Petroleum Reserve (SPR). The SPR has the capacity to store 700 million barrels of petroleum in massive salt caverns in Louisiana and Texas. The SPR provides the U.S. with a reserve stockpile of vital petroleum as a hedge against a major disruption in oil imports.

Method of Analysis: Data was received from two agencies, DOE and NASA. No analysis was performed. Some minor extrapolation was applied to arrive at the amount in DOE fire departments, based on a reported estimate of 90 gallons carried by the on-base department at Rocky Flats, Colorado. (Note: Data for the U.S. Coast Guard was included under the Military use sector.)

**Estimated Quantities (Gallons of AFFF Concentrate):**

Department of Energy	27,400
Strategic Petroleum Reserve	26,400
DOE Fire Departments	1,000
<u>NASA</u>	<u>16,000</u>
Total	43,400

**Total estimate for the “Other Federal Agencies” use sector = 43,400 gallons**

Accuracy of the Estimate: The reported amounts are considered to be minimum numbers. There could be additional amounts in some other agencies, but any unreported amount is considered to be relatively small.

### **Civil Aviation (Airport ARFF)**

Application: Federal law requires that all airports operating regularly scheduled commercial flights, involving aircraft carrying more than 30 people, shall have fire fighting capability commensurate with the size of the aircraft. Federal Aviation Administration (FAA) regulations, described in Part 139 Title 14 of the Code of Federal Regulations (14 CFR Part 139), establishes and defines specific Aircraft Rescue and Fire Fighting (ARFF) indices, based primarily on the length of aircraft operating at an airport. Each commercial airport in the U.S. is assigned an index from A to E, in ascending order of aircraft size. Index A applies to small aircraft shorter than 60 feet. Index E covers large

aircraft whose length exceeds 200 feet, such as Boeing 747, Airbus A 340, and MD –11 aircraft. Based on the assigned index, 14 CFR Part 139 establishes in quantitative terms the minimum fire fighting capability, which essentially is defined by type, quantity and flow rate of foam fire fighting agents. While 14 CFR Part 139 establishes the absolute legal minimum requirements, the FAA encourages airports to provide greater ARFF capability. FAA Advisory Circular 150/5210-6C recommends agent quantities in excess of the legal minimum, more in line with the consensus standard published by the National Fire Protection Association (NFPA), NFPA Standard 403, “Aircraft Rescue and Fire Fighting Services at Airports”.

AFFF has become the standard foam agent at airports in the United States. Testing has shown that, for a given application rate, no foam agent can equal the performance of AFFF for airport applications. A pool of jet fuel burning under a fuselage can cause structural burn-thru of the aluminum aircraft skin within one to two minutes. Passenger survival in such cases is directly related to how fast the exposure fire is extinguished. Because of the unique ability of AFFF to rapidly suppress pool fires, both the FAA and NFPA essentially mandate the use of AFFF for airport ARFF applications. The author of this paper is not aware of a single airport in the U.S. that uses foam other than AFFF in ARFF vehicles. In fact, most airports cite the AFFF military specification when procuring foam.

Method of Analysis: Based on an FAA-maintained airport master directory, there are currently 366 certificated airports requiring on-site ARFF capability in the U.S. The number of airports within each ARFF index are as follows:

Airport ARFF Index	Number of Airports
A	134
B	96
C	82
D	30
E	24

It was not feasible to obtain detailed AFFF inventory data from every airport. Instead, two methods of analysis were used (1) a prior survey conducted by the NFPA was used to estimate the AFFF quantities in small Index A and B airports, and (2) an airport sampling and extrapolation method was used for Index C, D and E.

#### NFPA Survey for Index A and B Airports

In 1999, Michael J. Karter, Jr., NFPA Senior Statistician, conducted a survey of ARFF capabilities at airports throughout the United States. From his report, it is possible to calculate the amount of AFFF carried on ARFF vehicles. The table below shows the median “Q” for Index A and B airports extracted from the Karter report, where “Q” is defined as the water carried for foam production:

FAA Index	Median Q (Gals)
A	1540
B	3000

By knowing total water quantity, it is possible to calculate the amount of AFFF concentrate by factoring in the typical size of a concentrate tank as a function of carried water. The design of ARFF vehicles is governed by NFPA Standard 414, “Aircraft Rescue and Fire Fighting Vehicles”. NFPA 414 requires AFFF concentrate tanks to have enough concentrate for two complete fills of water. Thus, for Type 6 AFFF, the concentrate tank would be required hold an amount of AFFF concentrate equal to at least 12% of the water tank capacity. Since it is common practice in the industry for ARFF vehicle manufacturers to size foam tanks for Type 6 concentrate, even if the customer ultimately uses Type 3 foam, the vehicle concentrate tank will still hold a quantity equal to at least 12% of the water volume. Thus, the amount of AFFF concentrate carried on ARFF vehicles at Index A and B airports can be calculated by multiplying the amounts in the table above by 12%, as shown in the following table.

FAA Index	Median Q (Gals)	AFFF on Vehicles (Gals)
A	1540	185
B	3000	360

In addition to the quantity of foam carried on ARFF vehicles, the FAA also requires an on-airport reserve foam supply equal to twice the amount carried on the vehicles. Twice the amount carried on vehicles would be 24 % (2 x 12%) of the water tank capacities. The total AFFF for each Index A and B airport would therefore be the sum of the AFFF carried on ARFF vehicles added to the required reserve supply, as shown in the following table.

FAA Index	AFFF on Vehicles (Gals)	AFFF Reserve Supply (Gals)	Total AFFF Per Airport (Gals)
A	185	370	555
B	360	720	1080

Multiplying the estimated quantity of AFFF for each Index A and B airport by the number of airports in each category yields the following overall estimates for AFFF concentrate quantities:

FAA Index	Number of Airports	Estimated AFFF Per Airport	Total AFFF Per Index
A	134	555	74,370 Gals
B	96	1080	103,680 Gals

### Sampling and Extrapolation for Index C, D and E Airports

The Karter survey also covered Index C – E airports. However, NFPA 403 has been revised since the Karter survey was compiled. Since the more recent NFPA 403 has considerably increased required agent amounts, especially for larger airports, it was considered that the Karter survey numbers may not represent a current snapshot for Index C – E. It was decided to obtain actual data from selected airports within C – E and then extrapolate to the population of airports within the respective index. Accordingly, questionnaires (see Appendix B) were sent to several airports within Index C – E.

The following 34 airports, representing 25 % of the 136 total airports within Index C – E, provided detailed inventory data on their AFFF inventory for ARFF purposes (summaries of the responses are shown in Appendix C):

#### Index C Responders to Questionnaire

El Paso, TX	Omaha	Sacramento, CA
Kansas City	Orange County, CA	San Antonio, TX
Little Rock, AR	Oakland, CA	Savannah, GA
Nashville, TN	Portland, ME	Syracuse, NY
Oklahoma City	Richmond, VA	Washington Reagan

#### Index D Responders to Questionnaire

Baltimore/Washington	Las Vegas	Pittsburgh, PA
Indianapolis, IN	New Orleans	Salt lake City
LaGuardia, NY	Ontario, CA	Tulsa, OK

#### Index E Responders to Questionnaire

Atlanta, GA	Los Angeles (LAX)
Boston Logan	Miami, FL
Dallas/Fort Worth	Newark, NJ
Denver	Orlando, FL
Kennedy (JFK)	Washington Dulles

Each of the listed responders provided actual to-the-gallon data on their airport AFFF inventory. The calculated per airport averages of the responses are as follows:

Index C Airport Average	3,055 Gallons
Index D Airport Average	4,763 Gallons
Index E Airport Average	6,719 Gallons

The final step was to extrapolate from the reported figures, by multiplying the average amount per airport within each index by the number of airports comprising each index, as shown in the following table:

FAA Index	Number of Airports Per Index	Average Reported Quantity per Index	Estimated Total Gallons per Index
C	82	3,010	246,820 Gals
D	30	4,763	142,890 Gals
E	24	6,719	161,256 Gals

Estimated Quantities (Gallons of AFFF Concentrate):

Based on the numbers derived in the tables above, the estimated quantity of AFFF concentrate for the civil aviation (ARFF) use sector is:

Index A Airports	74,370
Index B Airports	103,680
Index C Airports	246,820
Index D Airports	142,890
Index E Airports	161,256
Total	729,016

**Total estimate for the “Civil Aviation (ARFF)” use sector = 729,000 gallons**

Accuracy of the Estimate: There is always an unknown margin of error when extrapolating from reported numbers to an entire population. However, these numbers are considered representative of the use sector. Also, since the Karter estimates for Index A and B were compiled 5 years ago, there is no reason to expect that the inventory for any of the airports would have gotten smaller.

**Civil Aviation (Aircraft Hangars)**

Application: The national consensus standard for fire protection in this use sector is NFPA Standard 409, “Standard on Aircraft Hangars”. This standard has been adopted by reference by most regulatory bodies and airport authorities, and is the benchmark for insurance underwriting for fire insurance coverage for commercial hangars. NFPA 409 was revised in 2001 to permit high expansion foam in lieu of low expansion foam, such as AFFF. However, existing hangars would in all probability conform to pre-2001 editions, which essentially mandates overhead foam sprinkling for the entire hangar augmented by underwing foam protection. Hangars requiring foam are classified as

Group I, if the floor area exceeds 40,000 square feet, or Group II, if the floor area exceeds 20,000 square feet. Most existing foam systems utilize AFFF. Typical Group I hangars would require AFFF concentrate varying between 4 – 6,000 gallons, while Group II hangars would require systems containing 2 – 3,000 gallons of AFFF concentrate. Hangars for wide-body aircraft would all fall within the Group I designation.

Method of Analysis: Data on total AFFF quantity in hangar systems was provided by a sampling of airports, as follows:

Airport	FAA Airport Index	Hangar AFFF Quantity (Gallons)
Los Angeles International (LAX)	E	24,000
Dallas Fort Worth (DFW)	E	40,000
Washington Dulles	E	10,400
San Antonio, TX	C	5,000
Washington Reagan	C	3,100
Savannah, GA	C	2,700
JFK, NY	E	2,000
Pittsburgh, PA	D	1,000
Omaha, NE	C	750

Similarly, hangar AFFF quantities were also reported by a small sampling of companies (airline, aircraft manufacturer, and delivery service) as follows:

Company	AFFF Quantities in Hangars (Gallons)
Delta Airlines	65,000
US Air	9,000
United	39,500 *
American	40,700 **
Federal Express	100,000
Boeing	57,450

\* Data covers Denver, San Francisco, and Indianapolis

\*\* Data only covers Tulsa, OK

Extrapolation of this limited sampling could be accomplished two ways: by extrapolating based on the total number of certificated airports as defined in the previous sector, or extrapolation based on companies that would operate aircraft hangars.

For the first method, the numbers shown for airports in the table above, broken down by FAA Airport Index ( 76,400 gallons for 4 Index Es, 1,000 gallon for 1 Index D, and 11,550 gallons for 4 Index Cs), would be extrapolated to the entire population of certificated airports. However, it is believed that the one response from an Index D

airport (1,000 gallons for Pittsburgh) is not representative of the overall index. It is not logical that Index D airports would have a lower average quantity than Index C airports, which accommodate smaller aircraft. Index D should fall somewhere between C and E. Accordingly, a more realistic figure of 5,000 gallons for each Index D is assumed. Extrapolation to the entire population (24 Index Es, 30 Index Ds, and 82 Index Cs) would yield hangar AFFF quantities as follows:

Index E:  $76,400 \times 24/4 = 458,400$  gallons

Index D:  $5,000 \times 30/1 = 150,000$  gallons

Index C:  $11,550 \times 82/4 = 236,775$  gallons

This would sum to over 800,000 gallons. Hangars operated outside the realm of certificated airports, such as by Boeing and other aircraft manufacturers, as well as by companies such as FedEx and other package delivery services, would have to be added to this number to arrive at an overall total. This might suggest a total of approximately 950,000 gallons. This number would assume that airports have hangars in proportion to their designated FAA airport index, which may not be entirely valid.

The second method would extrapolate based on companies that operate aircraft hangars. The table above that shows AFFF quantities by companies indicates that Delta Airlines operates hangars having 65,000 gallons of AFFF concentrate, United has almost 40,000 gallons just at Denver, San Francisco, and Indianapolis. American has over 40,000 gallons just at Tulsa, while US Air has 9,000 gallons overall. Adding in hangar quantities for Boeing and Federal Express brings the total to over 300,000 gallons. The airlines not listed (Continental, Northwest, Southwest, Alaska Airlines among others), and additional United and American amounts at other than the four airports listed, might be expected to add at least 200,000 gallons among them. To this would have to be added quantities for smaller airlines, as well as quantities for hangars not operated by airlines, such as by private aircraft maintenance companies, as well as other aircraft manufacturers and delivery services, which conceivably add an additional 250,000 plus gallons. This might also lead to an overall estimate of at least 750,000 gallons.

Taking the mid point of these two methods of estimation yields an overall estimate of 850,000 gallons.

Estimated Quantities (Gallons of AFFF Concentrate):

An estimate of 850,000 gallons is assumed for this use sector.

**Total estimate for “Civil Aviation (Aircraft Hangars)” use sector = 850,000 gallons**

### **Merchant Ships/Off-Shore Platforms**

Application: According to a representative of the US Coast Guard, nearly all AFFF on US flag vessels is found on oil tankers. Coast Guard requirements are spelled out in Title 46 (Shipping) of the Code of Federal Regulations. The applicable section, 46 CFR 34.20, mandates that, with few exceptions, the cargo tank deck must be protected by a deck foam system consisting of installed and portable foam nozzles that provide coverage of the entire open deck of the cargo area. The supply of foam liquid must be sufficient to provide total flow for a minimum of 20 minutes. Similar requirements are contained in the provisions of the International Convention for the Safety of Life at Sea (SOLAS) published by the International Maritime Organization and endorsed by maritime Classification Societies such as the American Bureau of Shipping. The foam concentrate is not required to be AFFF, and in fact many merchant ships carry non-AFFF concentrate, such as fluoroprotein or protein foam.

There are also similar requirements for foam systems to be installed on helicopter landing pads on off-shore platforms, especially if helicopter fueling is permitted on the deck. Though not a “merchant ship” per se, off-shore platforms are included in this use sector because of the foam requirement similar to that provided for tankers.

Method of Analysis: In attempting to estimate the quantity of AFFF on merchant tankers, the first step was to try and determine the number of U.S. flag tankers, and then to estimate how many would have AFFF as opposed to non-AFFF agents. Unfortunately, no database was available from the Coast Guard. However, the web site of the U.S. Maritime Administration estimates that there are 130 tankers in the U.S. merchant fleet, but states that some are under the Military Sealift Command (covered earlier under the military use sector) and further states that not all are self-propelled. The Military Sealift Command (MSC) web site claims that there are “64 commercial U.S. tankers other than those operated by MSC,” but implies that that number only applies to ocean-going vessels, which would not include some tankers with deck foam systems operating strictly within coastal waters (such as the Great Lakes or shuttle tankers operating between the Alaskan pipeline and west coast refineries). Similarly, the World Factbook On-line states that there are 81 petroleum tankers in the U.S. fleet, but only lists ocean-going vessels larger than 1,000 gross tons. A major operator of commercial tankers, Keystone Shipping, estimated that there are at least 50 ocean going tankers in the U.S. merchant fleet, but confirmed that many non-ocean-going tankers have foam systems as well. Based on the above information, it appears reasonable to assume that there are roughly 100 U.S. tankers with deck foam systems.

Based on information provided by former and current employees of AFFF manufacturers, it was estimated that about 50 % of the U.S. tanker fleet would have AFFF, that nearly all of that would be alcohol-type AFFF and that the amount per tanker would range from 500 to 1500 gallons of concentrate. The bottom line assumption therefore is that there are 50 tankers with AFFF (alcohol type) and the average quantity per tanker is 1000 gallons, which yields an estimate of 50,000 gallons.

It was also estimated that there are about 200 offshore drilling rigs with helicopter landing pads, most in the Gulf of Mexico. Additionally, it was estimated that half of the total landing pads have foam systems and that the average quantity of AFFF per system would be 200 gallons. This equates to an estimate of 20,000 gallons of AFFF.

Most experts contacted also stated that some merchant ships might carry AFFF for portable foam eductors, machinery space protection or other miscellaneous foam applications. No quantitative estimate was obtained. Based on the size of the U.S merchant fleet (estimated at 220 vessels larger than 1000 gross tons), an estimate of 10,000 gallons for miscellaneous merchant ship applications, less than 50 gallons per ocean-going vessel, is considered reasonable

Estimated Quantities (Gallons of AFFF Concentrate):

Tankers	50,000
Offshore Rigs	20,000
Misc. Vessels	10,000
<hr/>	
Total	80,000

**Total estimate for “Merchant Ship/Off-Shore Platforms” use sector = 80,000 gallons**

**Fire Departments (Non-Aviation)**

Application: Most fire departments throughout the country carry small quantities of AFFF for situations where they may encounter flammable liquids, such as an overturned tanker truck or an automobile accident with ruptured fuel tanks. Pumper trucks generally carry at least two 5 gallon containers with portable foam eductors. Some pumpers also have built-in concentrate tanks (NFPA Standard 1901, “Automotive Fire Apparatus” specifies the design features for foam systems on fire department vehicles). Some larger departments also deploy foam tenders, which can bring large quantities of AFFF to the scene of major incidents involving flammable liquids. Additionally, fire departments adjacent to waterways usually have fireboats, many of which carry AFFF that can be discharged through high flow rate deck monitors (NFPA Standard 1925, “Marine Fire-Fighting Vessels” covers foam systems on fire boats).

Method of Analysis: According to the U.S. Fire Administration, there are approximately 32,000 fire departments in the country. They further estimate that those departments deploy a total of 68,000 pumpers. Contact was made at random with fire departments throughout the country (see Appendix D), concerning their practices relative to AFFF.

The following municipal/county departments all reported that they carry AFFF on their pumpers:

New York City	Washington, D.C
Los Angeles, CA	Boston, MA
Galloway Township, NJ	Dallas, TX
Anne Arrundel County, MD	Wilmington, NC
Fallston, MD	Charlotte, NC
Phoenix, AZ	Daytona Beach, FL
Montgomery County, PA	Hyattsville, MD
Bolton, CT	Rockville, MD
Andover, CT	Gaithersburg, MD
Southington, CY	Manchester, NH
Worcester, MA	Manchester, CT
Glen Echo, MD	Keene, NH

In fact, every single fire department contacted claimed to carry some AFFF. Responses from Los Angeles, New York City, Dallas, Washington, D.C., and Boston are significant in view of their size. Los Angeles reported that the fire department has almost 25,000 gallons deployed on structural pumpers, a couple of foam tenders and fireboats. New York City reported that all pumpers in the city carry two 5 gallon cans of MilSpec AFFF and that there are 5 foam tenders in the city (each carrying about 1,000 gallons of AFFF concentrate). Dallas and Washington each average more than 20 gallons per pumper, while Boston has 15 gallons per pumper plus special foam rigs. Several departments also reported carrying some AFFF on special HazMat vehicles, squad/rescue trucks, and even some spare cans on ladder trucks. Usually, some spare containers are also stored in the fire stations for re-supply.

A reasonable number for all fire departments nationwide may be 20 gallons per pumper, which would also factor in amounts on other vehicles, fireboats and fire station reserves. Based on the number of pumpers, this estimate equates to 1,360,00 gallons of concentrate.

Estimated Quantities (Gallons of AFFF Concentrate):

68,000 pumpers x 20 gals/pumper = 1,360,000 gallons of AFFF concentrate

**Total estimate for the “Fire Departments (Non-Aviation)” use sector = 1,360,000 gallons**

Accuracy of the Estimate: The estimate for this use sector is speculative and involves a considerable degree of extrapolation from a small sample to a very large population.

### **Oil Refineries**

Application: The distillation of crude petroleum into refined products entails the processing, movement and storage of large quantities of flammable liquids. Fire fighting foam plays an essential role in providing protection against potentially devastating fires. Because of its proven performance advantages, over the years AFFF has become the dominant foam agent of choice.

Method of Analysis: Estimating quantities of AFFF for this major use sector was accomplished by extrapolation of inventory data provided by persons with special knowledge of fire protection, and specifically foam quantities, in this industry.

According to the National Petrochemical and Refiners Association there are 149 active refineries in the U.S., with a total petroleum processing capability of approximately 16.8 million barrels per day (bpd). Over 40 % of the refineries are located in Texas, Louisiana, and California, with those three states producing 54 % of the total national refinery output. Refinery size varies from about 5,000 bpd to over 500,000 bpd, with the median size of all refineries in the U.S. being about 75,000 bpd. Gasoline production is about 55 % of the total refinery output, or approximately 9 million bpd.

The map below (Figure 2) shows the location of all active refineries in the U.S. The map is segregated by Petroleum Administration for Defense (PAD) Districts. PAD Districts were established in World War II for purposes of administering the allocation of this vital resource. The two different symbols on the map allow differentiation between “large” (greater than 75,000 bpd) and “small” refineries (less than 75,000 bpd).

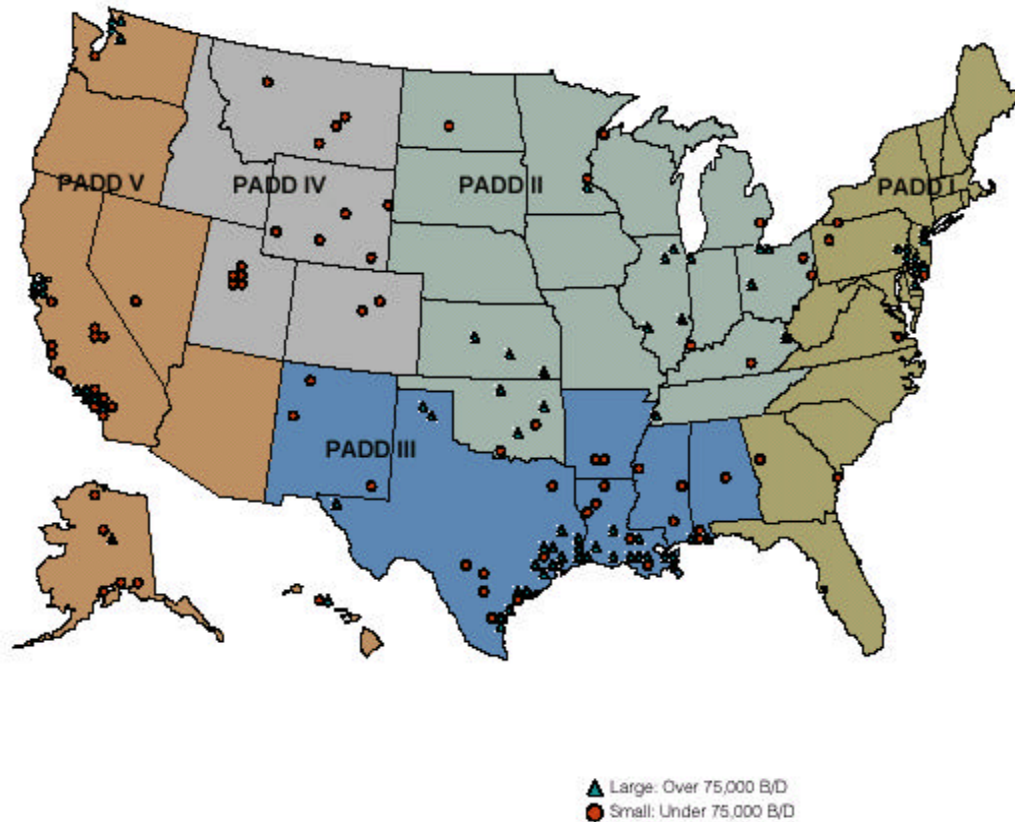


Figure 2 - Refineries in the 50 U.S. States

Data on AFFF quantities in refineries was obtained from three principle manufacturers of AFFF products and systems. The data was derived from market surveys conducted on the petro-chem industry.

One manufacturer provided AFFF inventory figures for 43 refineries with a total combined petroleum output of 6.89 million bpd, representing about 43 % of the total refinery capacity in the U.S. Of the 43 refineries on the list, 27 had outputs exceeding 100,000 bpd. The total amount of AFFF in those refineries, as reported in the data, is 953,027 gallons (approximately 686,000 gallons installed in fire protection systems and hardware, and an additional 267,000 gallons held as emergency reserve). The total AFFF in the reported refineries equates to one gallon of AFFF concentrate for every 7.2 bpd of refinery output ( $6.89 \text{ million} \div 953,027$ ). Extrapolating this amount to the total U.S. refinery output of 16.8 million bpd yields a total of 2.33 million gallons of AFFF at refineries nationwide ( $16.8 \div 7.2$ ), or an average of 15,600 gallons of AFFF concentrate per refinery.

Data from another manufacturer extrapolates to a smaller overall industry estimate. They provided a listing, not broken down by specific facilities, which showed 1,790,000 gallons of AFFF concentrate in 182 petro-chem facilities. It was estimated that 2/3 of the

overall petro-chem quantities applied to refineries, which would indicate approximately 1,194,000 gallons of AFFF contained in 121 refineries. This would equate to about 9,900 gallons of AFFF per refinery, which is roughly 2/3 of the per refinery estimate above. This same manufacturer also provided an estimate of 1 gallon of AFFF concentrate for every 11.5 bpd of refinery output, which would extrapolate to about 1.46 million gallons.

In summary, the overall estimate for this sector varies from 2.33 million gallons to 1.46 million gallons. Taking an average of the two would produce an estimated quantity of AFFF for U.S. refineries of approximately 1.9 million gallons

Estimated Quantities (Gallons of AFFF Concentrate):

**Total estimate for the “Oil Refineries” use sector = 1,900,000 gallons**

**Other Petro-Chem Industries**

Application: This sector covers the application of AFFF for fire suppression in petroleum facilities other than refineries. This includes petroleum blending facilities, fuel farms, fuel tank loading racks, marine fueling terminals, miscellaneous chemical companies and flammable liquid storage and processing areas. Fire protection for these hazardous operations consists of AFFF delivery systems of various designs, including overhead sprinklers, fixed nozzle deluge systems, remote control monitors and in some cases manually directed discharge streams. The design and installation of AFFF systems in this sector is governed by various NFPA standards, especially the following:

NFPA 11 – “Low, Medium, and High Expansion Foam”

NFPA 30 – “Flammable and Combustible Liquids Code”

NFPA 16 – “Foam-Water Sprinklers and Foam-Water Spray Systems”

Method of Analysis: The development of an estimate of AFFF quantities in this sector was very difficult. Unlike the refinery sector, there is no overseeing authority or central database of either the number of actual facilities or AFFF inventory. Estimates were derived essentially from anecdotal information and opinions of persons with varying degrees of knowledge of this sector. Much of the information obtained could best be described as “expert guesses.”

- The data covering refineries discussed above also included some non-refinery estimates. About 1/3 of the total (597,000 gallons of AFFF in 61 facilities) was attributed to major blenders, fuel farms and chemical companies.
- Based on discussions with three major distributors of AFFF agents and systems to the petro-chem industry, estimates of the amount of AFFF installed in this industry over the last 10-20 years range from 3-4 million pounds. It is not clear

how much of this agent would be in refineries and hangars and how much would be in systems that have been decommissioned over that period of time.

- Two manufacturers reported that they maintain an emergency/strategic reserve of AFFF for the petro-chem industry. The total AFFF emergency reserve (not included under the refinery sector) is about 100,000 gallons.
- In collecting information on the civil aviation (ARFF) sector, six airport Fire Chiefs volunteered information on airport fuel farms. These figures were not included under the airport data, and are more appropriately included here since they represent AFFF installed systems protecting petroleum aircraft fuel storage. The following fuel farm quantities were reported:

Atlanta Hartsfield Airport	
Delta Fuel Farm	385 gallons AFFF
AGI Fuel Farm	330
International Fuel Farm	330
Pittsburgh Airport	
Airport Fuel Farm	1,000
Washington Dulles Airport	
Airport Fuel farm	30,000
Washington Reagan Airport	
Airport Fuel Farm	2,400
Richmond, VA Airport	
Millionair Fuel Farm	100
Aero Fuel Farm	300
John Wayne Orange County	
Airport Fuel Farm	300
LAX	
Airport Fuel Farm	5,000

The total AFFF for fuel farm protection at these six airports is over 40,000 gallons. This total may not be representative due to the large system at Washington Dulles. Additionally, it is not known how many airports have installed AFFF systems protecting fuel farms. However, in view of the fact that nearly all airports store fuel for aircraft fueling, an estimate of 200,000 gallons of AFFF for airport fuel farm systems seems reasonable.

Overall the estimates for this sector are somewhat conflicting and incomplete. The refinery input implies less than 1 million gallons, but the inclusiveness of the data is not known. The estimates from distributors suggests 3-4 million gallons, but much of that

number could also include refineries and hangars and it is also likely that some systems installed in prior years may have been decommissioned. AFFF manufacturers' strategic reserve for the petro-chem industry and the estimate of AFFF in airport fuel farms seems reasonable.

Determination of more precise figures for this use sector would necessitate further study. However, an estimate of 2 million gallons may be appropriate, with an understanding that there is a wide margin of error in the 2 million gallon figure.

Estimated Quantities (Gallons of AFFF Concentrate):

**Total estimate for the "Other Petro-Chem" use sector = 2,000,000 gallons**

**Miscellaneous Applications**

Application: There are applications of AFFF that don't fit neatly within the designated use sectors. Additionally, there are undoubtedly some unique AFFF delivery systems that have not been identified. Examples of likely applications not addressed elsewhere are as follows:

**Helicopter Landing Pads:** Heliports are not certificated by the FAA, and are exempt from complying with FAR Part 139. However, the FAA has issued an "Advisory Circular" on heliports (AC # 150/5390-2A) recommending that fire protection features should meet NFPA criteria. NFPA 418, "Heliports", defines foam system requirements for helicopter landing facilities. For roof-top heliports, AFFF systems shall be provided at an application rate of 0.1 gpm per square feet of landing pad area, with a discharge duration of at least 5 minutes for fixed systems and 2 minutes for AFFF hose lines. A Web Site maintained by the CIA estimates there are 155 "public use" heliports in the U.S. The number of heliports having AFFF protection was not determined, but the New York Port Authority did provide information on one such roof-top facility: the Downtown Manhattan Heliport. This heliport has remotely activated oscillating foam monitor nozzles supplied by a 300 gallon AFFF concentrate tank. No doubt there are many similar heliports in the U.S.

**Training Facilities:** Many training schools have converted to gas or propane-fueled fire simulators, using foam surrogates in lieu of actual fire fighting foam. However, it is known that some still use AFFF. For example, it was reported that in Texas alone, both the regional school in Corpus Christie and Lamar University still conduct training with AFFF. The New York Port Authority reported they maintained a stock of over 3,000 gallons of AFFF for training purpose at their Police Academy at JFK.

**Non-Airport ARFF:** There are some ARFF vehicles with AFFF that operate at other than FAA certificated passenger airports. For example, Boeing reported that they operate their own ARFF vehicles at their facilities, with an estimated AFFF quantity on those vehicles of 9,000 gallons of concentrate. Federal Express also reported that they operate

3 or 4 ARFF vehicles, with a total of about 1500 gallons of AFFF.

Portable Extinguishers: Portable extinguishers, both hand-held and wheeled, are commercially available for protecting miscellaneous industrial flammable liquid hazards.

Reserve Stocks: As with any product, AFFF manufacturers and distributors maintain some in-stock quantities of AFFF to fill customer's orders. The amount was not determined, but surely constitutes several thousand gallons.

Unidentified Uses of AFFF: No doubt, throughout the country, there are other unique uses of AFFF that have not been identified

Method of Analysis: It is difficult to estimate the total amount of AFFF in these miscellaneous applications. An arbitrary "guesstimate" of 150,000 gallons is assumed for this category, with a potentially wide margin of error.

Estimated Quantities (Gallons of AFFF Concentrate):

**Total estimate for the "Miscellaneous Applications" use sector = 150,000 gallons.**

### **Summarization of Estimates for All Use Sectors**

<b>AFFF Use Sector</b>	<b>Estimated Quantity AFFF Concentrate (Gallons)</b>	<b>Possible Margin Of Error ± %</b>	<b>Likely Range Of Actual Quantity (Gallons)</b>
U.S. Military	2,836,500	± 5 %	2,694,675 – 2,978,325
Other Federal	43,400	- 0 + 25 %	43,400 – 54,250
Aviation (ARFF)	729,016	-5 + 20 %	692,565 – 874,819
Aviation (Hangars)	850,000	± 25 %	637,500 – 1,062,500
Merchant Ships/Offshore	80,000	± 25 %	60,000 – 100,000
Fire Depts (non-aviation)	1,360,000	± 35 %	884,000 – 1,836,000
Oil Refineries	1,900,000	± 25 %	1,425,000 – 2,375,000
Other Petro-Chem	2,000,000	± 35 %	1,300,000 – 2,700,000
Misc Applications	150,000	± 35 %	97,500 – 202,500
<b>Total</b>	<b>9,948,916</b>		<b>7,834,640 – 12,183,394</b>

Rounding off to the nearest tenth of a million gallons, the AFFF inventory in the U.S. is estimated at:

**9.9 million gallons, within a range of 7.8 to 12.2 million gallons**

## **Determining Estimates of Types of AFFF**

As defined previously, the estimate is expressed as gallons of AFFF concentrate. The utility of the data can be enhanced by showing a breakdown of the overall estimate based on the following AFFF characteristics:

- Suitability for use on alcohol
- Mixture rate
- Specification (MilSpec or UL listed)
- Manufacturer

When originally developed 40 years ago, AFFF was only intended for use on conventional hydrocarbons distilled from raw crude oil. In the early days AFFF had only limited effectiveness on flammable liquids that were water soluble or polar solvents, such as alcohol, acetone or ketones. This led to the ultimate development of “alcohol type” AFFFs, often referred to as ATC (alcohol type concentrate), AR (alcohol resistant), or “Universal” foam. ATC AFFFs are formulated to produce a floating polymeric skin for foam buildup on water-miscible fuels. This polymeric skin protects the foam from breakdown. The presence of these AFFFs in the market place allows an end-user to select a concentrate based on the nature of the flammable liquid threat. If the liquid of concern from a fire standpoint was a conventional hydrocarbon such as kerosene, gasoline, diesel fuel, jet fuel, fuel oil, etc, than conventional AFFF would be used. On the other hand if the threat fuel could be an alcohol or other water-soluble liquid, than an ATC AFFF would be the agent of choice.

Mixture rate was discussed earlier under the report section entitled “Constituents of AFFF Concentrate”. As presented previously, conventional AFFF is usually designated as 3 % or 6 % concentrate (or sometimes referred to as Type 3 or Type 6). To a lesser extent, there is also 1 % concentrate on the market. For ATC AFFFs, the designation of mixture rate is more complicated, since ATCs usually have one recommended mixture rate for conventional hydrocarbons and another rate for alcohol-type fuels. For example, an ATC AFFF may be classified as a “3 x 6”, meaning it should be proportioned at 3 % for conventional hydrocarbons and at 6 % for alcohol. There is a recent trend toward deployment of “1 x 3” ATCs, which may in the long run lead to an eventual reduction in the overall amounts of concentrate required.

Determining the manufacturer of an AFFF concentrate can be significant from an environmental standpoint. ECF-based AFFF agents are known to contain and break down into PFOS and PFOA. Telomer-based AFFF agents do not contain or break down into PFOS. An EPA workgroup recently determined that telomer-based AFFF agents are not likely to be a source of PFOA or its homologues.

Similarly, estimating the total quantity of concentrate that has been qualified to the AFFF Military Specification (MilSpec) can be significant from an environmental standpoint. Generally speaking, MilSpec AFFF will have a higher fluorine content than AFFFs qualified to less stringent specifications, such as those of Underwriters Laboratory (UL). As stated earlier, essentially all AFFF marketed in the U.S. is either MilSpec qualified or UL listed.

Limited data was received on the specific types of AFFF in each use sector. However, it is considered that sufficient information was provided to detect overall tendencies within major use sectors and to permit “ballpark” estimates to be offered on the amount of each type comprising the approximate 9.9 million gallons.

#### Conventional Vs ATC AFFF

Very little of the military inventory is ATC, except for about 165,000 gallons on some Coast Guard certified ships of the Military Sealift Command. Similarly, most of the merchant ship inventory is ATC. No ATC is used in civil aviation ARFF, and little or none in aircraft hangars. Maybe 50 % of the AFFF in the fire department and miscellaneous categories are of the ATC type. On the other hand, ATC is by far the primary type of AFFF in oil refineries and perhaps 50% of the inventory in other petro-chem facilities.

#### 3 % Vs 6 % AFFF Concentrate

The highest usage of 6 % AFFF is in the military, largely reflecting the near-exclusive use of 6 % type on Navy ships. It is estimated that about 1.3 million gallons of 6 % AFFF is in the military use sector. Of all the data submitted by civil aviation (ARFF) and aircraft hangars, less than 15 % of the total was 6 % AFFF, which for these two sectors would equate to less than 250,000 gallons. Use of 6 % AFFF is also considered to be in the minority in fire department applications and in the miscellaneous sector.

#### MilSpec Vs UL Listed Concentrate

It is estimated that over 90 % of all AFFF in the military/Federal sector is MilSpec AFFF (the primary exception being UL listed AFFF on some Coast Guard certified vessels of the Military Sealift Command). MilSpec AFFF predominates in the civil aviation ARFF sector as well. Based on replies from queried airports, it is estimated that 75 % of the AFFF in use at airports is MilSpec qualified. On the other hand, UL listed AFFFs would be in the majority in all other use sectors, with MilSpec AFFF estimated to comprise only about 40 % of the AFFF in aviation hangars and approximately 25 % of merchant ship use. The relative amount of MilSpec AFFF in the remaining use sectors is much lower, reflecting to some extent the widespread use of ATC concentrates by fire departments, in oil refineries and for petro-chem applications. The military specification does not cover ATC concentrates.

### ECF-based Vs Telomer-based AFFF

It is estimated that 75 % of the military AFFF inventory is ECF-based product. This is not surprising since for most of the past 30 years 3M was the primary supplier of MilSpec AFFF to the DOD stock system. About 18 % of the airport ARFF inventory was ECF-based, which extrapolated for the whole sector would be about 130,000 gallons. For aircraft hangars, ECF-based comprises about 25 % of the total, or roughly 200,000 gallons. ECF-based is the most predominant AFFF in oil refineries. Data submitted by one manufacturer showed 47 % of refinery AFFF as ECF-based, while data from another manufacturer indicated that over 75 % was ECF-based. Considering that the refinery data was a few years old, perhaps 50 % would be a good average for both the refinery and petro-chem sectors, which equates to over 2 million gallons of ECF-based product for those two sectors.

### **Estimates of AFFF Types**

The brief discussion above suggests that the overall estimate of 9.9 million gallons can be broken down into the following rough estimate for the different types of AFFF:

ATC AFFF: 4.0 million gallons

Conventional AFFF: 5.9 million gallons

3 % Type: 4.0 million gallons

6 % Type: 1.9 million gallons

Telomer-based AFFF: 5.3 million gallons

MilSpec: 1.5 million gallons

UL: 3.8 million gallons

ECF-based AFFF: 4.6 million gallons

MilSpec: 2.6 million gallons

UL: 2.0 million gallons

## Appendix A

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## Appendix B

### Sample of Airport Questionnaire

Airport AFFF Inventory Survey Form

Airport Name

FAA Airport Index

3% Concentrate

6 % Concentrate

Amount of AFFF Concentrate on ARFF Vehicles\*

gals

gals

Amount of Spare AFFF Concentrate\*\*

gals

gals

Miscellaneous Amounts of AFFF Concentrate (Specify miscellaneous uses)\*\*\*

gals

gals

gals

gals

gals

gals

Total Amount of AFFF Concentrate at Airport

gals

gals

\* Include amounts on all airport vehicles that carry AFFF including reserve crash trucks, structural pumpers with AFFF, pick-up trucks with TAUs, etc.

\*\* Include all reserve amounts of AFFF concentrate stored on the airport.

\*\*\* Portable extinguishers, fuel farms, aircraft hangar sprinkler systems, etc.

AFFF Manufacturer/Brand Name

(Example: Angus/Tridol M 3%, Ansul/Ansulite AFC-5-A, Buckeye/3MS, Chemguard/C 301 MS, National/Aer-O-Water 6EM, etc)

Name of Person Completing Form:

Phone Number:

Email:

Please send completed form to: Robert L. Darwin Hughes Associates, Inc

FAX: 410-737-8688

Email: rldarwin@comcast.net

Phone: 410-737-8677

## Appendix C

### Airport Responses to Questionnaire

## Reported Inventories from Index C Airports

Airport Index	Airport	AFFF on ARFF Vehicles (gals)	Spare AFFF (gals)	Total AFFF (gals)
C	El Paso, TX	1190	3165	4355
C	Kansas City	1108	1780	2888
C	Little Rock	600	1700	2300
C	Nashville	1620	1620	3240 *
C	Oakland	1730	4515	6245 **
C	Oklahoma City	615	1365	1980
C	Omaha	1030	1165	2200
C	Orange County	1920	1850	3770
C	Portland, ME	795	770	1565
C	Richmond	800	2000	2800
C	Sacramento	800	600	1400
C	San Antonio	1000	1200	2200
C	Savannah	1310	2260	3570
C	Syracuse	1220	2320	3540
C	Wash Reagan	1200	1900	3100 ***
Total				45,153 gals

\* 1035 gals of total is 6 % type concentrate

\*\* 175 gals of total is 6 % type concentrate

\*\*\* 3100 gals of total is 6% type concentrate  
Identified as 3M Company AFFF

Average quantity for 15 reported Index C Airports = 3010 Gals per Airport

### Reported Inventories from Index D Airports

Airport Index	Airport	AFFF on ARFF Vehicles (gals)	Spare AFFF (gals)	Total AFFF (gals)
D	Balt-Wash Intl	1260	2700	3960
D	Indianapolis	1420	2035	3455
D	La Guardia	1000	2840	3840
D	Las Vegas	1840	2625	4465
D	New Orleans	840	2000	2840
D	Ontario, CA	3375	3620	6995
D	Pittsburgh	3100	6200	9400
D	Salt Lake City	1600	3500	5100
D	Tulsa	1210	1705	2915 *
Total				42870 Gals

\* 565 gals of total is 6% type concentrate  
Identified as 3M Company AFFF

Average quantity for 9 reported Index D Airports = 4763 Gals per Airport

### Reported Inventories from Index E Airports

Airport Index	Airport	AFFF on ARFF Vehicles (gals)	Spare AFFF (gals)	Total AFFF (gals)
E	Atlanta	2640	3900	6540
E	Boston Logan	2500	7500	10000
E	Dallas Ft Worth	3090	1620	4720
E	Denver	3978	6985	10963
E	JFK	2000	7405	9405
E	LAX	2295	3000	5295
E	Miami	1655	2740	4395
E	Newark	1650	34000	35650
E	Orlando	2440	1720	4160
E	Wash Dulles	2000	3000	5000 *
Total				96128 Gals

\* All 5000 gallons is 6% type concentrate

Identified as 3M Company AFFF

Note: Newark not figured into average due to anomalous spare quantity

Average quantity for 9 reported Index E Airports = 6719 Gals per Airport

.

## Appendix D

### AFFF Carried by Fire Departments

## Estimates of AFFF Carried by Fire Departments

- Andover Fire Dept.  
Andover, CT  
30 gallons per pumper
- Anne Arundel County, MD  
10 – 15 gallons per pumper
- Bolton Fire Dept.  
Bolton, CT  
18 gallons per pumper
- Boston Fire Dept.  
Boston, MA  
Foam Units – 50 gallons per pumper  
Engines – 15 gallons per pumper
- Charlotte Fire Dept.  
Charlotte, NC  
35 gallons per pumper
- Dallas Fire Dept.  
Dallas, TX  
Total = 1220 gallons  
23 gallons per pumper
- Daytona Beach Fire Dept.  
Daytona Beach, FL  
15 gallons per pumper
- Fallston Fire Dept  
Fallston, MD  
10 gallons per pumper
- Gaithersburg – Washington Grove Fire Dept.  
Station 8 – Gaithersburg, MD  
Station 28 – Rockville, MD  
50 gallons per pumper
- Galloway Fire Dept  
Galloway Township, NJ  
15 gallons per pumper
- Glen Echo Fire Dept.

Bethesda, MD  
15 gallons per pumper

- Hyattsville Fire Dept.  
Hyattsville, MD  
10 gallons per pumper
- Keene Fire Dept.  
Keene, NH  
25 gallons per pumper
- Los Angeles City  
25,000 gals on structural pumpers  
Foam tenders and fire boats
- Manchester Fire Dept.  
Manchester, CT  
50 gallons per pumper
- Manchester Fire Dept.  
Manchester, NH  
30 gallons per pumper
- Montgomery County Fire Dept.  
Montgomery County, PA  
5 – 10 gallons per pumper
- New York City Fire Dept.  
10 gallons per pumper  
Plus 5 foam tenders (1000 gallons each)
- Phoenix Fire Dept.  
Most pumpers 40 gallons each
- Rockville Fire Dept.  
Station 3 - Rockville, MD  
25 gallons per pumper
- Southington Fire Dept.  
Southington, CT  
20 gallons per pumper
- Washington DC Fire/EMS Dept.  
Engines – 20 gallons per pumper  
Foam Units – 260 gallons per pumper
- Wilmington Fire Department

Wilmington, NC  
15 gallons per pumper

- Worcester Fire Dept.  
Worcester, MA  
45 gallons per pumper

Note: The quantities shown represent the responses of the individual fire departments to telephone inquiries conducted in early June 2004, in which each of the listed departments was asked:

How much AFFF concentrate do you carry on your pumper fire apparatus?